Detached Eclipsing Binaries for Parallax Measurements

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ABSTRACT

A list of 50 bright Detached Eclipsing Binaries proposed for precise parallax measurements for the FAME is presented. The eclipsing binaries, with precise distances and with photometric and double-line spectroscopic orbits determined, are essential for a full calibration of relations that could be used for very precise distance determination of globular clusters, LMC, SMC, and perhaps also M31 and M33.

It is expected that since 2004 the Full-sky Astrometric Mapping Explorer (FAME) will be operating from space (Horner et al. 1999). The spacecraft will determine, in particular, parallaxes with accuracy to 50 microarcseconds for stars between 5th and 9th visual magnitudes. In this connection the author was asked by Prof. Bohdan Paczyński to prepare a list of 50 bright detached eclipsing binaries, that would be - after having precisely measured distances - particularly good candidates for empirical calibration of the distance determination based on detached eclipsing binaries. This is a very old, and potentially excellent method; a large number of references, as well as the description of the method is provided by Kruszewski and Semeniuk (1999). A comparison between the distances based on eclipsing binaries (Lacy 1979) and Hipparcos parallaxes demonstrated that the method is indeed promissing (Semeniuk 2000), but there is plenty of room for an improvement.

The binary stars proposed for FAME program are expected to be subjects of a special treatement during the parallax measurements.

The proposed stars should fulfill the following imposed criteria:

1. They should be fainter than 5 and brighter than 9 visual magnitude.
2. Their distances should be smaller than 1 kps.
3. The primary and secondary minima of a star should have comparable depths.
4. Their spectral types should be from the range B0 - K9.
5. They should have no characteristics of chemical peculiarity in their spectra, *i.e.*, Am or Fm stars should be excluded.
6. Their components should have no intrinsic variability.

It would also be desirable from the point of view of a surface brightness-color relation that the spectral types be approximately uniformly cast by stars, with each spectral type represented by about 10 stars.

Table 1 contains proposed detached eclipsing binaries. They were selected generally from the *Hipparcos Variability Annex i.e.*, the Vol. 11 of the *Hipparcos Catalogue* (ESA 1997). This volume, in its Section "Periodic Variables", contains 410 stars classified as eclipsing binaries of the variability type EA.

The stars in Table 1 are arranged according to the spectral types. The columns of the table are generally self-explanatory. Comments must only be given to some of them. The depth of minima in Columns 4 and 5 are generally in V magnitude. The letters y or b, that follow some of the depth values, denote, that they are in y or b magnitudes of the Strömgren four–color *ubvy* system. The parallaxes in Column 8 were taken from the *Hipparcos Catalogue*, when their standard errors were less than 25% and we had no distance determination from the analysis of photometric and spectroscopic orbits. For stars with such distances, and with the Hipparcos parallax error greater than 20%, we preferred to place them in Column 8 instead of Hipparcos parallaxes. The parallax values and their errors, in such cases, were taken from available literature. In the case when no error was given in the literature we estimated it assuming the value for the relative error of parallax equal to 0.07. This value was obtained as the mean from the relative errors published in the literature. The parallaxes obtained from the photometric and spectroscopic elements are followed by asterisk. For the star V335 Ser with no parallax value in the literature we have estimated it using the spectral type - luminosity calibration (Lang 1992). It is denoted by a cross following the parallax value. Columns 11 to 14 (on the second page of the table) contain relative radii a_1 and a_2 of the components of the system and their errors σ_{a1}, σ_{a2} and Columns 15 to 18 their radial velocities K_1 and K_2 and their errors σ_{K1} and σ_{K2}, respectively. We can see that the accuracy both of the relative radii and the radial velocity amplitudes is generally on the level of the last figure of their values. Table 1 contains 35 systems with determined elements both of photometric and spectroscopic orbits. For the remaining 15 systems the author could not find in available literature any information concerning such orbits except for HP Dra and V2080 Cyg whose elements of spectroscopic orbits have recently been determined.

As we can see Table 1 is dominated by stars with the spectral types B, A and F. There are only a few stars with G spectral type and there are no systems with K type components except for one component of AI Phe. The reason for that is that we could hardly ever find, among the G and K spectral type binaries, stars with no signs of chromospheric activity. For the systems with G type components, that are placed in Table 1, we have no indications, at the moment, that they are chromospherically active. However, it is not excluded that future thorough photometric observations may indicate an RS CVn type variability in their light curves. This concerns particularly the two stars with short orbital periods *i.e.*, KR Aqr and UW LMi, as such variability in this spectral type depends strongly on the orbital period and is much more likely for systems with short orbital periods than for the stars with longer periods.

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Table 1

Nearby Eclipsing Binaries for parallax measurements

Name	HIP Number	Max [mag]	MinI [mag]	MinII [mag]	Spectral type	P [days]	π [mas]	σ_π [mas]
CW Cep	113907	7.59	0.40y	0.38y	B0.5V+B0.5V	2.73	1.30 *	0.08
QX Car	48589	6.64	0.55	0.37	B2V+B2V	4.48	1.32 *	0.09
CV Vel	44245	6.69	0.47	0.46	B2.5V+B2.5V	6.89	1.67 *	0.12
V760 Sco	80405	6.99	0.43	0.42	B4V+B4V	1.73	3.57 *	0.19
AG Per	19201	6.71	0.28	0.28	B4V+B5V	2.03	2.82 *	0.24
DI Her	92708	8.42	0.71	0.57	B5V+B5V	10.55	1.62 *	0.12
U Oph	84500	5.91	0.72b	0.61b	B5V+B6V	1.68	5.38	0.83
GG Lup	74950	5.59	0.61	0.30	B7V+B9V	1.85	6.34	0.72
KL CMa	31017	6.75	0.21	0.19	B8V	1.76	4.51	0.76
χ2 Hya	54255	5.65	0.29	0.27	B8V+B8V	2.27	4.08	0.68
AS Cam	25740	8.61	0.59	0.36	B8V+B9.5V	3.43	1.94 *	0.14
IQ Per	18662	7.73	0.52	0.14	B8V+A6V	1.74	3.64 *	0.20
CW CMa		8.58	0.40	0.39	B9V+B9V	2.12	3.03 *	0.30
V359 Vel	53806	7.63	0.20	0.18	B9V	4.54	3.65	0.73
AR Aur	24740	6.17	0.68	0.58	B9V+B9.5V	4.13	8.20	0.78
V451 Oph	90599	7.87	0.53	0.42	B9V+A0V	2.20	3.33 *	0.33
V821 Cas	118223	8.27	0.42	0.22	A0	1.77	5.38	0.91
V572 Per	15193	6.50	0.30	0.16	A0	1.21	7.90	1.03
V335 Ser		7.65	0.50	0.40	A0	3.45	3.98 +	0.80
PT Vel	45079	7.05	0.55	0.30	A0V	1.80	6.20	0.62
TZ Men	25776	6.19	0.66	0.16	A0V+A8V	8.57	9.35	0.50
VV Pyx	41475	6.58	0.50b	0.48b	A1V+A1V	4.60	5.13 *	0.26
V1647 Sgr	88069	6.94	0.67b	0.49b	A1V+A1V	3.28	8.70	1.40
CM Lac	108606	8.21	0.85	0.33	A2V+A8V	1.60	4.40	0.84
DV Boo	70287	7.60	0.22	0.12	A2	1.26	7.38	0.92
V397 Cep	270	7.41	0.37	0.33	A2	2.09	4.70	0.63
V805 Aql	93809	7.62	0.60	0.30	A2+A7	2.41	5.80	0.87
V364 Lac	112928	8.34	0.71	0.64	A3V+A4V	7.35	2.21 *	0.07
V1031 Ori	27341	6.02	0.43	0.32	A3V+A6V	3.41	4.65 *	0.54
V477 Cyg	98955	8.56	0.82	0.18	A3V+F2V	2.35	5.22	1.05
SZ Cen	67556	8.48	0.66b	0.62b	A7V+A7V	4.11	1.83 *	0.25
ZZ Boo	68064	6.80	0.44	0.44	F2IV+F2IV	4.99	8.88	0.78
TV Cet	15090	8.60	0.72b	0.46b	F2V+F2V	9.10	6.25 *	0.27
GV Dra	87576	8.53	0.58	0.28	F2	23.85	2.79	0.63
CW Eri	14273	8.43	0.52	0.40	F2V+F2V	2.73	5.95	1.25
RZ Cha	52381	8.10	0.43y	0.39y	F5V+F5V	2.83	5.43	0.63
V2080 Cyg	95611	7.48	0.40	0.38	F5	4.93	12.60	0.58
V1143 Cyg	96620	5.86	0.52	0.21	F5V+F5V	7.64	25.12	0.56
HS Hya	50966	8.18	0.54y	0.48y	F5V+F5V	1.57	11.04	0.88
V505 Per	10961	6.87	0.53	0.53	F5V+F5V	4.22	15.00	0.84
CD Tau	24663	6.75	0.55	0.52	F6V+F6V	3.44	13.66	1.64
DM Vir	69029	8.73	0.75b	0.75b	F7V+F7V	4.67	5.21 *	0.11
TZ For	15092	6.88	0.20b	0.05b	F7IV+G8III	75.67	5.86	0.96
AI Phe	5438	8.61	0.83b	0.20b	F7V+K0IV	24.59	6.17 *	0.23
UX Men	25760	8.22	0.76b	0.66b	F8V+F8V	4.18	9.93	0.62
KX Aqr	111162	8.23	0.44	0.37	F8/G0V	2.07	6.25	1.07
UW LMi	52465	8.45	0.40	0.30	G0V	3.88	7.73	1.08
GK Dra	82056	8.84	0.34	0.34	G0	16.96	3.37	0.69
HP Dra	92835	8.08	0.30	0.26	G5	10.76	12.45	0.72
QY Vel	48185	8.28	0.16	0.16	G5III	9.57	3.26	0.79

Table 1

Concluded

Name	$a1$	σ_{a1}	$a2$	σ_{a2}	$K1$ [km/s]	σ_{K1} [km/s]	$K2$ [km/s]	σ_{K2} [km/s]	Ref.
CW Cep	0.235	0.005	0.214	0.005	210	2	235	2	1
QX Car	0.144	0.003	0.136	0.003	167.0	1.1	182.5	1.0	1
CV Vel	0.117	0.001	0.113	0.001	127.0	0.30	129.2	0.44	1
V760 Sco	0.234	0.005	0.205	0.008	178	2	189	2	1
AG Per	0.2045	0.0045	0.1779	0.0045	173	2	189	2.5	2, 3
DI Her	0.0621	0.001	0.0574	0.001	110.7	0.5	126.6	1.2	1
U Oph	0.262	0.004	0.240	0.004	182	1	197	1	4
GG Lup	0.2000	0.0020	0.1450	0.0015	124.5	0.5	204.2	0.9	5
KL CMa									6
hi2 Hya	0.3283	0.0020	0.1615	0.0043	123.3	1.0	168.2	1.6	1
AS Cam	0.1499	0.0004	0.1111	0.0004	110.4	1.1	145.8	1.3	7, 8
IQ Per	0.231	0.002	0.142	0.001	101.8	0.9	206.4	1.6	1
CW CMa	0.1702	0.0034	0.1615	0.0065	127.6	0.8	135.1	0.6	9
V359 Vel									6
AR Aur	0.0977	0.0007	0.0996	0.0010	107.2	2.0	115.9	2.0	10
V451 Oph	0.2155	0.0020	0.1655	0.0020	129.3	1.3	152.3	1.5	1
V821 Cas									6
V572 Per									6
V335 Ser									11, 12
PT Vel									6
TZ Men	0.0722	0.0007	0.0513	0.0005	62.15	0.12	102.82	0.45	1
VV Pyx	0.1156	0.0010	0.1156	0.0010	103.6	0.4	103.7	0.5	1
V1647 Sgr	0.1226	0.0010	0.1116	0.0010	119.8	0.9	133.0	1.0	1
CM Lac	0.185	0.002	0.165	0.001	119.1	0.9	153.8	2.6	7
DV Boo									6
V397 Cep									6
V805 Aql	0.18	0.01	0.15	0.01	107.0	0.5	139.0	1.0	13, 14
V364 Lac	0.1126	0.0007	0.1248	0.0013	96.02	0.14	94.47	0.49	15
V1031 Ori	0.186	0.004	0.270	0.002	123.23	0.32	113.93	0.31	1
V477 Cyg	0.1441	0.0020	0.1167	00030	105	2	140	4	7, 16
SZ Cen	0.2022	0.0013	0.2541	0.0006	111.3	0.6	109.4	0.4	1
ZZ Boo	0.119	0.004	0.119	0.005	90.2	0.3	93.0	0.2	7, 17
TV Cet	0.059	0.001	0.050	0.001	67.4	0.8	73.8	0.9	13, 18
GV Dra									19
CW Eri	0.177	0.004	0.133	0.009	98.9	0.35	118.0	0.6	17
RZ Cha	0.186	0.001	0.186	0.001	108.2	0.6	107.6	0.9	1
V2080 Cyg					81.6		83.8		20
V1143 Cyg	0.059	0.001	0.058	0.001	88.2	0.20	91.1	0.4	1
HS Hya	0.1660	0.0009	0.1584	0.0009	121.73	0.30	125.38	0.35	21
V505 Per	0.0861	0.0022	0.0844	0.0048	88.93	0.14	90.30	0.14	22
CD Tau	0.1330	0.0010	0.1172	0.0013	96.8	0.5	102.1	0.5	23
DM Vir	0.1052	0.0010	0.1052	0.0010	90.65	0.22	91.05	0.22	1, 24
TZ For	0.0332	0.0007	0.0697	0.0009	40.80	0.54	38.81	0.06	1
AI Phe	0.0380	0.0005	0.0613	0.0010	50.90	0.08	49.24	0.07	1
UX Men	0.0918	0.0009	0.0868	0.0009	87.41	0.025	90.28	0.17	1
KX Aqr									6
UW LMi									6
GK Dra									6
HP Dra					62.3		64.5		20
QY Vel									6

References: 1) Andersen 1991; 2) Giménez and Clausen 1994; 3) Popper and Hill, 1991; 4) Holmgren *et al.* 1991; 5) Andersen *et al.* 1993; 6) ESA 1997; 7) Lacy 1979; 8) Khaliullin and Kozyreva 1983; 9) Lacy 1982; 10) Nordström and Johansen 1994; 11) Bastian and Born 1997; 12) Kozarovets *et al.* 2000; 13) Popper and Etzel 1981; 14) Popper 1981; 15) Torres *et al.* 1999; 16) Giménez and Quintana 1992; 17) Popper 1983; 18) Jørgensen 1979; 19) Dallaporta *et al.* 2000; 20) Kurpińska-Winiarska *et al.* 2000; 21) Torres *et al.* 1997; 22) Marschall *et al.* 1997; 23) Ribas *et al.* 1999; 24) Latham *et al.* 1996;